A reprint from

American Scientist

the magazine of Sigma Xi, The Scientific Research Honor Society

Blind Mind's Eye

People with aphantasia cannot visualize imagery, a trait that highlights the complexities of imagination and mental representation.

Adam Zeman

Which is darker: the green of grass or the green of a pine tree? Does a squirrel have a short or a long tail? Is a walnut larger than a hazelnut? Do Labradors have rounded ears? To answer questions such as these, you probably summoned up images of the mentioned items to inspect them in your "mind's eye." When you enjoy a novel, you likely come away with a visual impression of the characters and scenes described—which can lead to that familiar disappointment if the book is turned into a movie: "He looked nothing like I'd imagined him!"

Most of us can conjure images to order: Visualize the Sun rising above the horizon into a misty sky—or your kitchen table as you left it this morning. But it turns out that 1 to 3 percent of the population entirely lack the ability to visualize—a condition called *aphantasia*—whereas others have *hyperphantasia* and experience imagery as vivid as actual sight. These imagery vividness extremes are prime examples of invisible differences that are easily overlooked but are salient features of the inner lives of those concerned. Understanding how such differences arise can help us learn about the many ways the mind can implement imagination and mental representation.

The Science of Imagery

Imagery involves the sensory experience of items in their absence: When we visualize a pine tree or the rising Sun, most of us have an experience that is a bit like seeing. But we can form imagery in other sense modalities too: We "hear" the sound of distant thunder, "feel" the touch of velvet, or imagine running for a bus by engaging auditory, tactile, and motor imagery, respectively. Olfactory imagery is more elusive, but many of us can relish the scent of a rose or shrink from the smell of sewage. To some degree, we can evoke absent emotions, imagining a breath of sadness or a sudden jolt of surprise. Although this article focuses on visual imagery, the broad principles seem to apply to imagery of all types.

Experiences of imagery are ubiquitous. They contribute to our recollection of the past (think of your last holiday) and our anticipation of the future (how will you spend next weekend?). They figure in our daydreams and our night dreams. They have been implicated in creative work in both the sciences and the arts. Albert Einstein wrote: "I very rarely think in words at all," relying instead on "more or less clear images which can be voluntarily 'reproduced' and combined. . . ." The novelist Joseph Conrad emphasized the importance of imagery to his craft: "My task . . . is, by the power of the written word to make you hear, to make you feel—it is, before all, to make you see."

Research over the past century has taught us much about the psychology of imagery generally and its basis in the brain. An impressive series of experiments by Stanford University psychologist Roger Shepard, Harvard University neuroscientist Stephen Kosslyn, and others showed that imagery is indeed, as intuition might suggest, an echo of perception. If we are asked to shift our mental gaze between two objects on a map that we have memorized, we answer more swiftly if they lie close together rather than far apart, as if we were scanning the map with our eyes before we respond; in deciding whether one object is a rotated version of the other, the timing of the decision depends on the extent of the rotation. A beautifully simple observation epitomizes work along these lines: If visualizing is really like seeing, visualizing something bright should cause a constriction of the pupil, as would occur when looking at something bright. Bruno Laeng at the University of Oslo has shown that, indeed, if we switch our mental image from a bright sky to a night sky or a cloudy one, the pupil duly dilates (*see figure at the top of page 112*).

But there is more to imagery than it being simply "weak perception." Let's say that I ask you to imagine a tulip, and you succeed—what color was it, by the way?—you engage a whole team of more basic cognitive abilities: You must be awake and attentive, you require your command of the English language to decode the instruction, you need your memory to retrieve your knowledge of tulips and their appearance, you need to use your executive function to orchestrate the whole process, and you use your perceptual system to generate the sense of "looking at" a tulip.

This description reminds us that, like any cognitive act, forming an image is a process rather than an instantaneous event. A measurable amount of time passes between receiving the instruction to "visualize a tulip" and becoming able to inspect and manipulate its image in the mind's eye. On the basis

QUICK TAKE

A condition called *aphantasia* affects 1 to 3 percent of the population. Aphantasics lack the ability to visualize imagery—a term that includes all the senses, not just sight.

A survey about imagery vividness from 1880 was the first to document the condition, but it remained a little-studied phenomenon until the past few decades.

Aphantasia does not imply a lack of imagination, which indicates that the brain has a wide range of methods for cognitive representation, some more abstract than experiential.

Artefact/Alamy Stock Photo

***Wonderland* by Adelaide Claxton (1841–1927) depicts the mental imagery (here, a smoky imaginary figure) that our brains regularly conjure up while reading or while doing any other task where we are asked to visualize. People with aphantasia cannot create these mental images.**

of a series of behavioral experiments like those described above that he and his team undertook in the 1980s, Kosslyn described four key processing steps in our engagement with images. First, images must be *generated*: This step involves mobilizing information about how things look and using it to create a representation of the visualized item in what he called the "visual buffer," a broad description for relevant, visually oriented regions of the brain. These images tend to fade rapidly, probably because the visual brain is designed to deal with rapidly changing scenes. Keeping an image in mind requires *maintenance*, Kosslyn's second processing step. If we want to use an image to answer a specific question—does your tulip have a long stem?—we need to *inspect* it, which is the third step; if we want to manipulate the image, such as twirling our tulip, some *transformation* is called for, the final step.

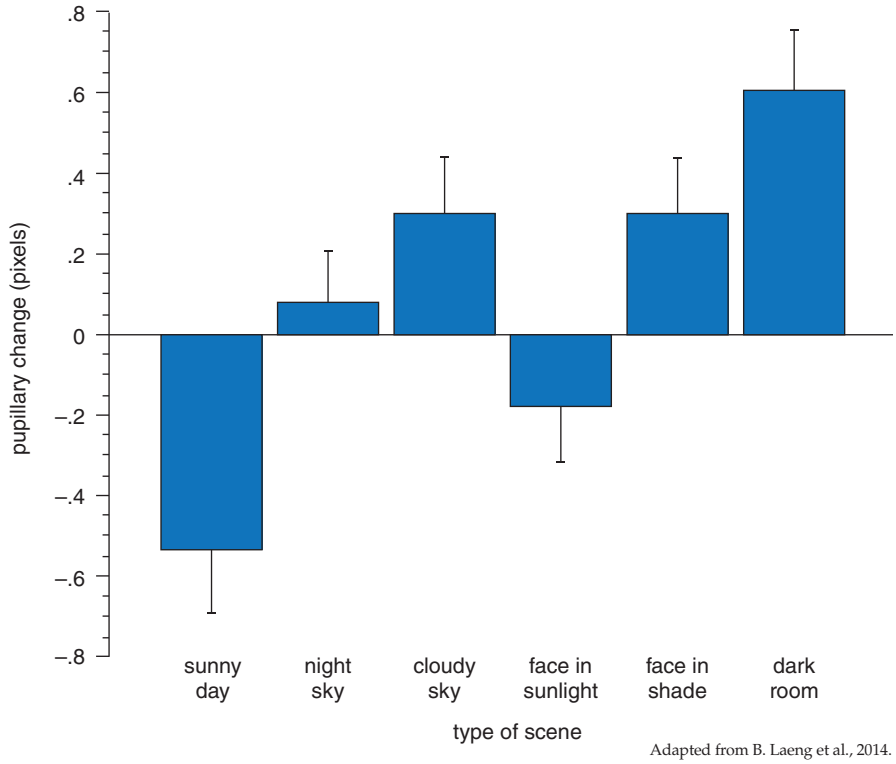
It is now almost half a century since one other fascinating line of evidence began to illuminate the science of imagery. Functional brain imaging relies on the simple principle that the brain is like muscle: When it becomes active in a task, the blood flow to activated regions ramps up. We can observe this change in several ways, most commonly using magnetic resonance imaging that is sensitive to local changes in oxygen concentrations. Two years ago my colleague Crawford Winlove identified 40 studies that had examined brain activation during imagery tasks. The regions he and others have identified (*see figure at the bottom of page 112*) are in keeping with the cognitive processes required to call a tulip to the mind's eye—areas in the frontal and parietal lobes linked to cognitive control, attention, and eye movements; areas linked to language processing; areas involved with memory; and visual cortices in the occipital and temporal lobes. The leading edge of such research is now focused on "mind reading," which is the effort to decode the contents of the mind's eye using brain-imaging data.

Studies examining the time course of acts of visualization in the brain highlight another, intuitively obvious, difference between imagery and perception. When we *see*, information streams in from the eyes to the brain, driving activity that spreads through the visual system and deep into the brain, allowing us, among other things, to recognize what we see. Visualization is "vision in reverse": The brain begins with a decision or instruction—"imagine a tulip"—and uses its stored knowledge of appearances to drive activity within the visual system that leads to the experience of imagery.

Imagery, in brief, allows us to simulate sensory experience "offline," enabling at least a partial reenactment of our past encounters with the world. The usual explanation for *why* we have imagery is that it ultimately enhances our ability to predict the future and act effectively within it. This purpose may be true, but recent findings somewhat complicate this story.

Rediscovering Aphantasia

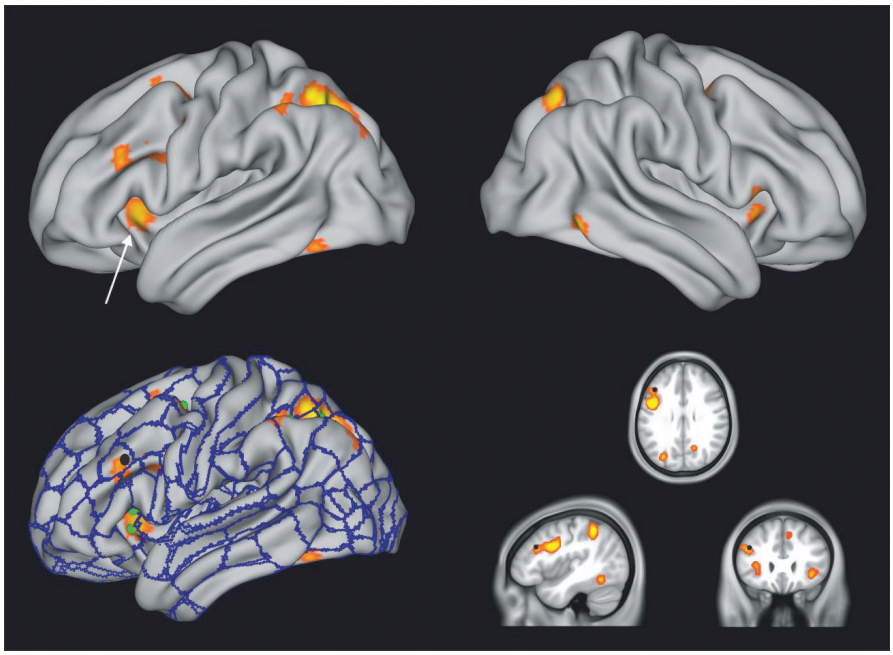
Sir Francis Galton was a Victorian scientist with a passion for measurement, which was misapplied in his role in the development of eugenics. But his "breakfast table questionnaire," published in 1880, was probably the first



Adapted from B. Laeng et al., 2014.

Imagery studies show that imagination can cause physical responses, demonstrating that visualization is connected to vision. In this case, data show that people's pupil dilation will change as they visualize brighter or darker imagery.

systematic attempt to measure the vividness of imagery. The questionnaire invited participants to "think of some definite object—suppose it is your breakfast table as you sat down to it this morning—and consider carefully the picture that rises before your mind's eye." They were asked to comment on its degree of illumination, definition, and coloring. Galton initially circulated his questionnaire to 100 colleagues, mostly scientists, classifying their responses into those where "the faculty is very high," mediocre, or "at the lowest." To his astonishment, many of these "men of science" protested that "mental imagery was unknown to them . . . they had no more notion of its true nature than a colour-blind man, who has not discerned his deficit, has of the true nature of colour." When he began to sample persons "in general society," however, he found "an entirely different disposition to prevail. Many men, and a yet larger number of women, and many boys and girls, declared that they habitually saw mental imagery, and that it was perfectly distinct to them and full of colour." There were also some notable exceptions to the rule among his scientific friends. A certain Charles Darwin, Galton's much esteemed cousin, responded that his image of the breakfast table included some objects "as distinct as if I had photos before me."



Adapted from C. Winlove et al., 2018.

Combined results from hundreds of individuals show the brain areas consistently activated while visualizing. Those in the frontal and parietal lobes are linked to cognitive control, attention, eye movements, language processing, and memory, whereas areas in the occipital and temporal lobes are visual. The mesh at lower left allows standardized mapping of brain regions. The arrow at top left indicates the insula, an area involved in sensation that normally would be obscured by other brain regions.

Galton's questionnaire spawned many descendants. We have used psychologist David Marks's Vividness of Visual Imagery Questionnaire (VVIQ) in our own work (*see figure on page 113*). This questionnaire asks for vividness judgments about images of 16 scenes that are rated from "no image at all, you only 'know' that you are thinking of the object," scoring 1/5, to "perfectly clear and as vivid as real seeing," scoring full marks. Galton's intriguing observation that for some the "power of visualization was zero" was almost entirely neglected over the following century, despite a great flowering of research on imagery more generally. A single American psychologist, Bill Faw, researched the topic in the past few decades, estimating that around 2 to 3 percent of his undergraduate students, like Faw himself, were "wakeful non-imagers." Occasionally neurologists, starting in 1883 with Jean Martin Charcot, the father of French neurology, encountered patients who lost the ability to visualize following brain injuries or strokes, and a few psychiatrists, such as Jules Cotard in 1882, recognized that mood disorders could cause a dimming of imagery and sometimes its disappearance. But most research examining imagery vividness focused on people with mid-range vividness scores. It suggested that these scores were reasonably consistent over time, but they showed rather modest, unexciting correlations with other psychological abilities.

Barbara Aulicino

The Vividness of Visual Imagery Questionnaire (VVIQ) asks responders to visualize a number of unfolding scenes, such as: The Sun rises above the horizon into a hazy sky, the sky clears and surrounds the Sun with blueness, clouds form and a storm blows up with flashes of lightning, then a rainbow appears. Responders are then asked to rate their imagery from 1 to 5, with 5 being perfectly clear and as vivid as real seeing, 4 being clear and reasonably vivid, 3 being moderately clear and lively, 2 being vague and dim, and 1 being no image at all, just an awareness that you are thinking about this subject.

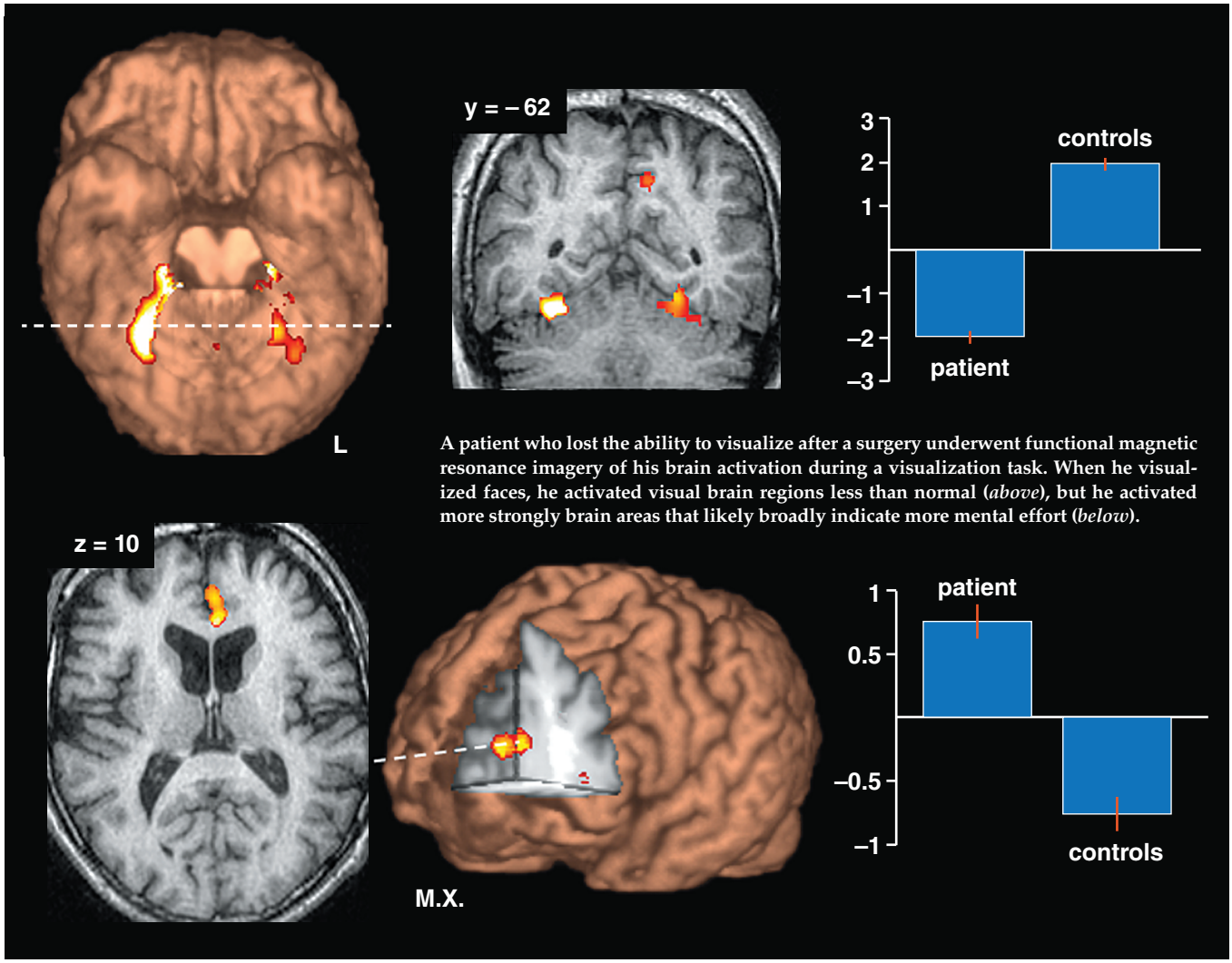
The first time I knowingly encountered a person without the ability to create imagery was in 2003. Identified only by the code MX for research purposes, he was a delightful retired surveyor in his mid-60s. Not long before I met him, he had undergone a cardiac procedure. Shortly afterward he realized that he could no longer visualize: He had previously relished his active mind's eye, for example, calling to mind images of friends, family, and places he had visited as he settled down to sleep. His dreams became avisual after the procedure, and he found that when he read, the novel would no longer create a visual world. His vision, by contrast, appeared entirely unaffected.

MX's account of his unusual symptoms was so compelling that we ultimately studied his brain activation in a visualization task using functional magnetic resonance imaging (*see figure on page 114*). When MX looked at famous faces, his pattern of brain activity was normal, but when he tried to visualize them, he failed to activate visual brain regions that came into play in our control participants. This difference suggested a satisfying neural correlate for the subtle but distinctive change in experience that he reported.

I found MX's case fascinating but did not anticipate what followed. The science journalist Carl Zimmer wrote an accessible account of our research in *Discover* magazine in 2010. Over the next few years, my colleagues Sergio Della Sala and Michaela Dewar and I were contacted by 21 people who recognized themselves in Zimmer's description of MX—with the key difference that they had *never* been able to visualize. Their accounts were quite consistent. They usually became aware of this idiosyncrasy in their psychological makeup in early adulthood. It intrigued rather than dismayed them. Most respondents described rather poor autobiographical memory. Most still dreamed visually despite their lack of wakeful imagery. About half of them told us that they lacked imagery in all sense modalities, not just the visual. Some described affected relatives. Oddly, all but two were men.

I felt that this phenomenon deserved an appropriate name. The terms used in the neurological literature, such as *defective revisualization* and *visual irreminiscence,* were unwieldy. I consulted a colleague trained in classical philosophy, David Mitchell of the New College of Humanities in London, who suggested that we borrow from Aristotle, one of the Greek fathers of philosophy. Aristotle's name for the mind's eye, in his work *De Anima* (*Of the Soul*) was φαντασία, or *phantasia*. We prefixed an *a,* denoting absence, to coin the term *aphantasia*, the lack of a mind's eye. Words are

Aristotle's name for the mind's eye was *phantasia,* so we prefixed an *a,* denoting absence, to coin the term *aphantasia*.



A patient who lost the ability to visualize after a surgery underwent functional magnetic resonance imagery of his brain activation during a visualization task. When he visualized faces, he activated visual brain regions less than normal (*above*), but he activated more strongly brain areas that likely broadly indicate more mental effort (*below*).

Adapted from A. Zeman et al., 2010.

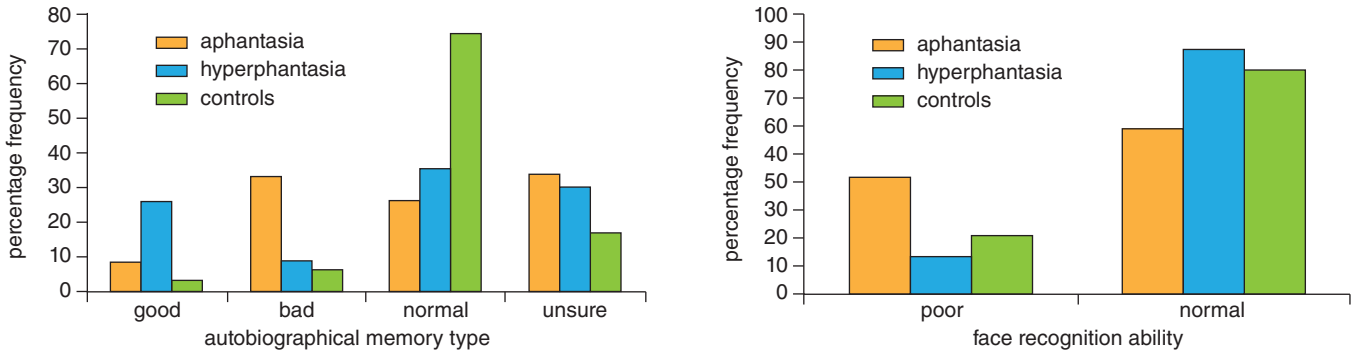
powerful tools. To my surprise, this simple coinage, published in a letter describing our 21 aphantasic contacts, triggered an avalanche of interest.

Widespread press coverage of the word and the phenomenon that it describes has since led around 14,000 people to get in touch by email. The majority have described various forms of aphantasia. Fewer people reported experiences from the opposite end of the vividness spectrum, with exceptionally vivid imagery; we termed this *hyperphantasia*. We were struck by the strong emotion expressed in many of the messages: "This is unbelievable. I've gone my entire life attempting to explain that I cannot picture things in my head"; ". . . a phenomenon that feels like a secret I've been keeping my whole life"; "so much of the world now makes sense"; "the craziest thing is knowing that I'm not alone." The cofounder of Mozilla Firefox, Blake Ross, posted a feisty account of his self-discovery as aphantasic that went viral: "I felt that transcendent warmth I've only known once before, when a dorky high school outcast in Florida stumbled on a group of California programmers who just seemed to 'get him.' It's the feeling of finding your people." We had connected with an unmet need.

Our flooded email inbox created a unique opportunity for further research. With the help of a team of student interns from the University of Exeter, I responded to the emails pouring in with a request to complete the VVIQ and another imagery questionnaire exploring a range of related topics. These questions asked, for instance, how and when people recognized their "difference," whether they dream in images, and whether they have trouble recalling episodes from their personal past. This exercise has allowed us to give a preliminary description of the psychological significance of imagery extremes from an analysis of 2,000 questionnaire pairs from people with lifelong aphantasia and 200 with hyperphantasia.

Vividness Extremes

Our first finding echoed Galton's observations about his scientific colleagues. Although there are many exceptions to this rule, aphantasia is associated with a bias toward mathematical and scientific occupations, whereas hyperphantasia is associated with more traditionally creative trades. Next, we identified two areas of difficulty for many people with aphantasia: Approximately one-third report poor autobiographical memory, whereas a (partially overlapping) third report a problem in recognizing faces; these complaints are rare among people with hyperphantasia (*see figure at the top of page 115*). These findings from the far extremes of imagery vividness harmonize with reports from other researchers that, in general, having more vivid imagery predicts richer, clearer, and less effortful recollection of autobiographical events. Similarly, a previous study of people with *congenital prosopagnosia*—a lifelong failure to recognize faces—had indicated that



Adapted from A. Zeman et al., 2020.

About a third of people with aphantasia report poor autobiographical memory, whereas a partially overlapping third report problems recognizing faces; these complaints are rare among people with hyperphantasia.

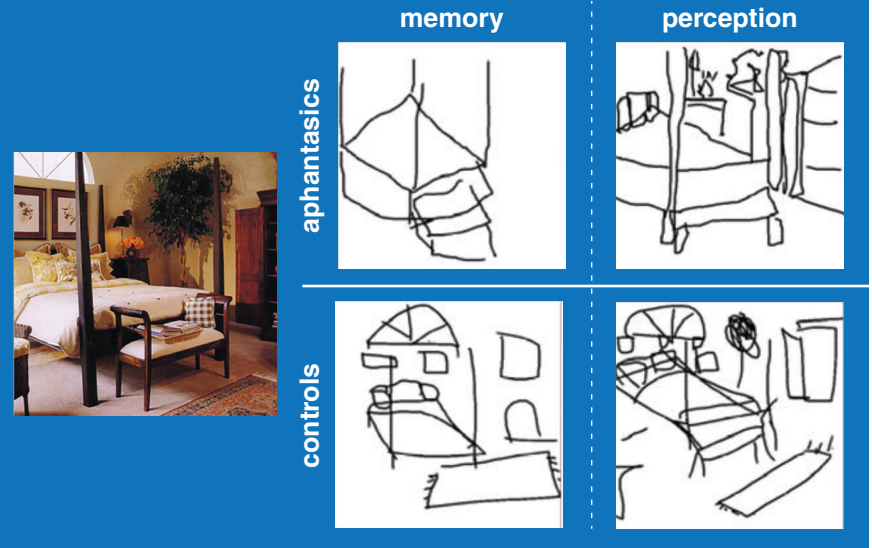
their visual imagery tends to be faint. A fourth association kept cropping up in our correspondence, although we had not specifically asked about this trait in our questionnaire: Many people with aphantasia reported they were on the autistic spectrum. At the opposite end of the spectrum, hyperphantasia appeared to be linked to *synesthesia*—the process by which some quality of experience, such as the sound of a vowel, is accompanied by an involuntary, unrelated, secondary experience, such as a color (*see "Synesthesia's Altered Senses" in the July–August 2020 issue*).

These associations were both intriguing, raising questions about the underlying mechanisms involved, and reassuring: They suggested that rather than being isolated oddities, visual imagery extremes are part of a bigger psychological picture. Our hundredfold larger sample gave us an opportunity to examine two other hints from our previous study of 21 participants. Around 60 percent of people with aphantasia reported visual dreams. This apparent discrepancy makes neurological sense, because the processes within the brain leading to dreaming and wakeful imagery are very different, so it is quite plausible that they should dissociate. People with aphantasia who dream avisually give fascinating descriptions of narrative, conceptual, and emotional dreams. Much as in our smaller study, around half of those with extreme imagery, both high and low, told us that all their senses were affected; for the remainder, some or all the other modalities of imagery were of normal vividness. This disparity suggests that both factors common to all sense modalities and factors specific to each influence the vividness of imagery.

Our estimates for the rates of extreme imagery in the community are about 1 to 3 percent for aphantasia, and 3 to 11 percent for hyperphantasia, depending on the threshold chosen for diagnosis. Many of our participants with extreme imagery report that other family members are similarly affected, allowing us to calculate a roughly tenfold increase in risk compared with the general population. It is too soon to judge whether this increase has a genetic basis. We hope to find out, but this effort will probably be hampered by a complexity that may well have occurred to you. Aphantasia is almost certainly not a single entity: It is a variation in experience that can occur in a range of settings—for example, in association with face recognition difficulty—or with lack of imagery in other senses. Its subtypes have yet to be clearly defined; but if they exist, their genetic background may well vary.

The Task of Triangulation

The story I have told you so far has relied on first-person evidence: what our participants have told us about their imagery and other aspects of their mental lives. This evidence is consistent: At around the time that we published our description of the psychological features of imagery extremes, another research group, led by imagery researcher Joel Pearson of the University of New South Wales in Sydney, Australia, described very similar findings. But



Wilma Bainbridge at the University of Chicago and her colleagues took the approach of quantifying aphantasia with drawing. Their study found that aphantasics lack object memory, but do not lack spatial memory. When the participants were shown a photograph of a real scene for 10 seconds and then asked to draw it from memory, aphantasics recalled fewer objects in the scene, but had lower incidence of mistakenly adding objects not in the photograph. However, when aphantasics were then asked to pick out the image of the scene they had been shown from a set of scenes, they did as well as controls, or people with average imagery vividness. When the aphantasics were asked to copy that scene while looking at the image, there was also no difference from controls.

Adapted from W. Bainbridge et al., 2021.

you may be skeptical about first-person evidence altogether. People are not entirely reliable witnesses of their mental lives. Descriptions of experience seem a good point of departure for psychological research. But if imagery extremes are significant, it should be possible to triangulate these first-person reports with more objective measurements, applying both behavioral tests and neural, brain-based approaches.

This work is underway. Pearson had previously used the idea that imagery is like weak perception to develop an ingenious measure of imagery strength. Briefly, his method uses the finding that a visual image formed in the mind's eye can influence subsequent perception in much the same way as a faint visual stimulus presented externally. The extent of this influence can be measured to provide a relatively objective estimate of imagery strength. In people with aphantasia, the influence is undetectable, suggesting that, indeed, they are failing to form visual images at all.

A second elegant experiment from Pearson's lab is also telling. His team asked people with and without aphantasia to read a series of scary descriptions, such as a swimmer's view of an approaching shark, which would evoke vivid imagery in most of us. They found that people with aphantasia failed to show the marked change in skin conductance observed in control participants without aphantasia (*see figure at right*). This difference was not because of an overall reduction in emotion, as the aphantasic participants showed a normal reaction to photos of scary scenes.

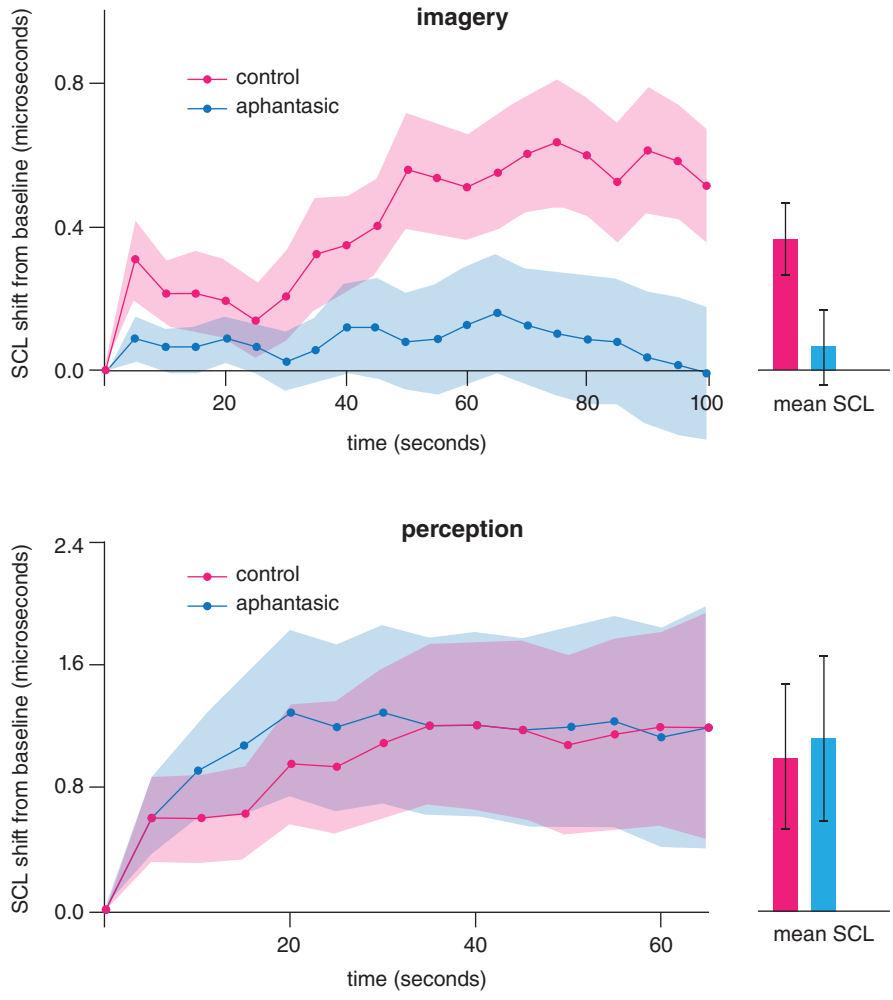
My team has recently used standard psychological tests to measure memory and imagination in people with aphantasia, average imagery, and hyperphantasia. Tests examining memory for verbal and visual material over intervals of half an hour did not distinguish the groups. But there were marked differences when we compared the richness of the description of personally significant past and imagined events. This result meshes well with the accounts given by some—though not all—people with aphantasia of relatively scant autobiographical memory (*see figure on page 117*).

Neural studies of aphantasia are also at an early stage. We have preliminary evidence that neural connectivity between frontal and posterior visual regions of the brain is stronger in the resting brain in people with hyperphantasia than in people with aphantasia. Other candidate explanations include differences in the area of visual cortices, which Pearson has shown to be related to differences in the strength and accuracy of imagery using his weak-perception technique. There is also evidence that variation in the excitability of visual regions can influence imagery strength. These possibilities are not mutually exclusive, and more than one of these hypotheses may prove correct.

Imagery Versus Imagination

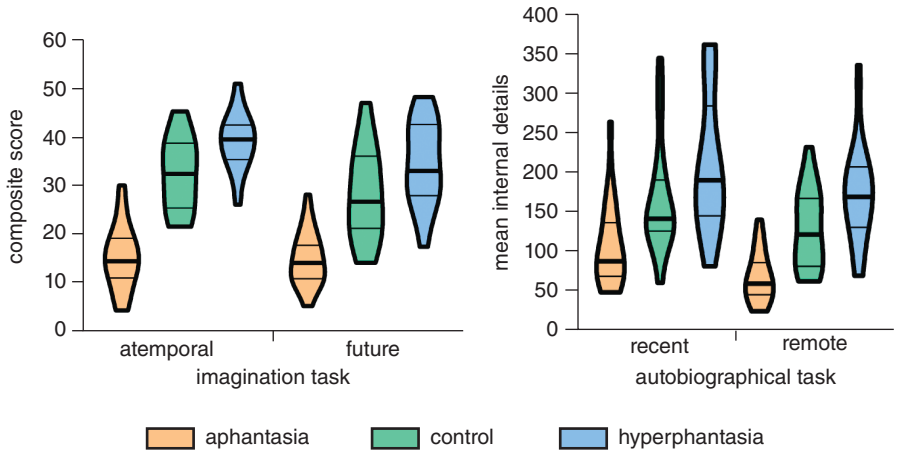
Imagination—defined as our ability to represent, reshape, and reconceive things in their absence—is one of the defining powers of the human mind. Its central importance contributes to the interest in imagery extremes, as imagery is, for most of us, a prominent ingredient of our imaginings. The fortunate opportunity to study large numbers of people with aphantasia and hyperphantasia prompts some general reflections.

First, are aphantasia and hyperphantasia "disorders"? In general, I think not. They are intriguing variations in human experience, analogous to synesthesia, which, like aphantasia, affects around 2 percent of the population. Both extremes of imagery vividness have interesting psychological associations, but neither is a barrier to leading a rich, creative, and fulfilling life. I suspect that the two extremes of the vividness spectrum will prove to have balanced advantages and disadvantages. They are, however, occasionally symptomatic of disorder: Aphantasia, for example, can sometimes result from a stroke, a head injury, or an episode of depression. So if someone who has previously had imagery suddenly loses it, it's reasonable to try to find out why.



Adapted from M. Wicken et al., 2019.

When viewing a progression of scary images, people with or without aphantasia showed a physiological fear response, measured as a change in their skin conductance level (SCL) that indicates autonomous nervous system arousal (*bottom*). But when read a description of a scary scene, only people with aphantasia lacked a physiological fear response (*top*).



Adapted from F. Milton et al., 2020. https://psyarxiv.com/j2zpn

Violin plots, named for their shape, show both the range and frequency of data (thick horizontal lines show median scores). For a task in which people are asked to describe imaginary scenes, either in an imagined future (for example, next New Year's Eve) or without any specific temporal location, the plots show the richness of the narratives produced by people with aphantasia, hyperphantasia, and average imagery vividness (*left*). Differences also arise when the same groups are asked to recollect recent or remote episodes from their personal past (*right*).

Second, does aphantasia imply an absence of imagination? The answer is a clear no. Among those people who contacted us because our description of aphantasia matched their own experience were the prolific neurologist Oliver Sacks, the pioneering geneticist Craig Venter, Pixar President Ed Catmull, and Mozilla Firefox cocreator Blake Ross. In an unexpected twist, over the past five years more than 100 aphantasic visual artists have been in touch with us, which has allowed my colleagues, artist Susan Aldworth and cultural historian Matthew MacKisack, to mount an exhibition of aphantasic and hyperphantasic art. Imagination is a much richer and more complex capacity than visualization. Aphantasia illustrates the wide variety of representation available to human minds and brains; visual imagery is by no means the only one.

Third, does aphantasia imply a verbal cognitive style? This connection seemed likely to me when I first began to think about this topic. If you lack a mind's eye, I mused, presumably you will tend to be more interested in sounds and words than visual images. There may be some people with aphantasia for whom this description is true, but for several reasons I am now doubtful that this hypothesis about aphantasia is generally applicable. For one thing, many people with aphantasia love the visual world, and some of them, aphantasic artists, devote their lives to depicting it. For another, about 50 percent of people with extreme imagery report that *all* modalities of imagery, including imagery of sounds, are vivid in the case of hyperphantasia or dim to absent in the case of aphantasia. This result suggests that a more relevant distinction than verbal versus visual may be abstract versus experiential: For some of us, thought is closer to sensory experience, and for others, it's more remote. But it's possible that no single distinction is sufficient to capture the contrast between aphantasia and hyperphantasia, not least because it is unlikely that either is a single entity.

For some of us, thought is closer to sensory experience, and for others, it's more remote.

Finally, what is imagery for? Aristotle wrote, "The soul never thinks without a phantasm." He was wrong; aphantasia contradicts this view. That is not to say that imagery does not play a part in the thinking of those of us who have it. But conscious imagery, at least, does not seem to be essential. It seems that people with aphantasia, especially those lacking all forms of sensory imagery, must either use more abstract representations—such as those of language—in their thinking or unconsciously draw on imagery. We need more research to tease apart these alternatives.

It has been a privilege to share so many insights from our participants' inner lives. I keep a few favorites pinned to my board. "I'm in the dark here," wrote one contributor, quoting a famous line from *Scent of a Woman*; another mused, "There are lots of ways of being human," surely one of the key messages from this work; a third wrote poignantly, "I'm learning to love without images."

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